

DIFFUSION FLAME STABILIZATION

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Diffusion flames are commonly used for industrial burners in furnaces and flares. Oxygen/fuel burners are usually diffusion burners, primarily for safety reasons, to prevent flashback and explosion in a potentially dangerous system. Furthermore, in most fires, condensed materials pyrolyze, vaporize, and burn in air as diffusion flames. As a result of the interaction of a diffusion flame with burner or condensed-fuel surfaces, a quenched space is formed, thus leaving a diffusion flame edge, which plays an important role in flame holding in combustion systems and fire spread through condensed fuels. Despite a long history of jet diffusion flame studies, lifting/blowoff mechanisms have not yet been fully understood, compared to those of premixed flames.

In this study, the structure and stability of diffusion flames of gaseous hydrocarbon fuels in coflowing air at normal earth gravity have been investigated experimentally and computationally. Measurements of the critical mean jet velocity (U_{jc}) of methane, ethane, or propane at lifting or blowoff were made as a function of the coflowing air velocity (U_a) using a tube burner (i.d.: 2.87 mm) (Fig. 1, left). By using a computational fluid dynamics code with 33 species and 112 elementary reaction steps, the internal chemical-kinetic structures of the stabilizing region of methane and propane flames were investigated (Fig. 1, right). A peak reactivity spot, i.e., *reaction kernel*, is formed in the flame stabilizing region due to back-diffusion of heat and radical species against an oxygen-rich incoming flow, thus holding the trailing diffusion flame. The simulated flame base moved downstream under flow conditions close to the measured stability limit.

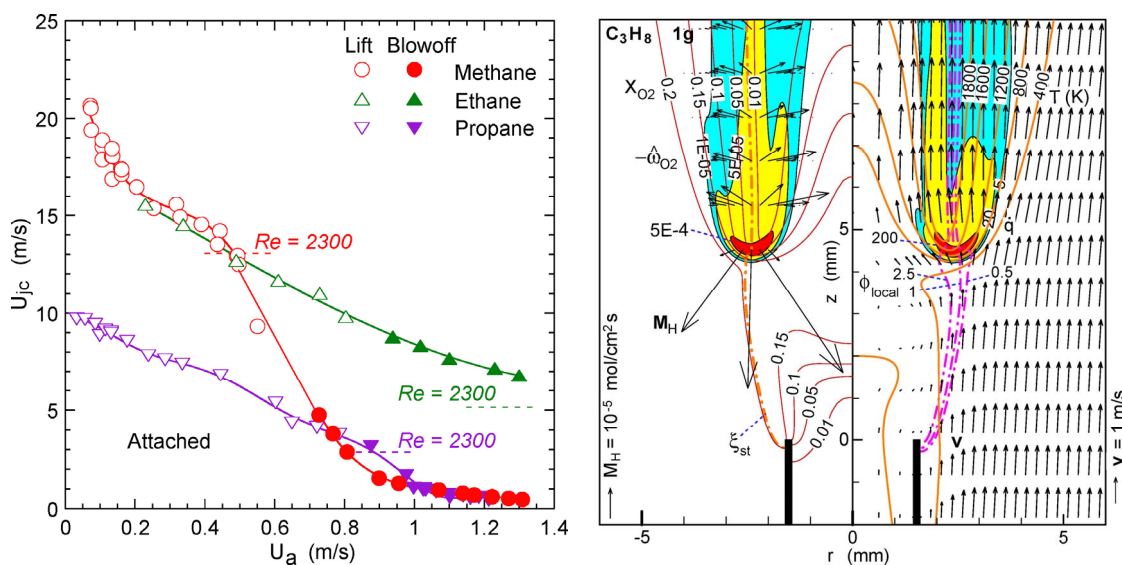


Figure 1 Measured flame stability limits (left) and calculated structure of a near-blowoff propane flame, $U_j = 0.12$ m/s, $U_a = 1.13$ m/s. (right). Calculated variables shown include the velocity vectors (\mathbf{v}), isotherms (T), total heat-release rate (\dot{q}), local equivalence ratio (ϕ_{local}) on the right half; the total molar flux vectors of atomic hydrogen (\mathbf{M}_H), oxygen mole fraction (X_{O_2}), oxygen consumption rate ($-\hat{\omega}_{O_2}$), and stoichiometric mixture fraction ($\xi_{st} = 0.060$) on the left half.

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